WORKSHOP

Measurement of luminance distributions in the field of view
for glare evaluations

HDR Cameras

Jan Wienold & Peter Hansen
Interdisciplinary Laboratory of Performance-Integrated Design (LIPID)
Ecole polytechnique fédérale de Lausanne (EPFL)

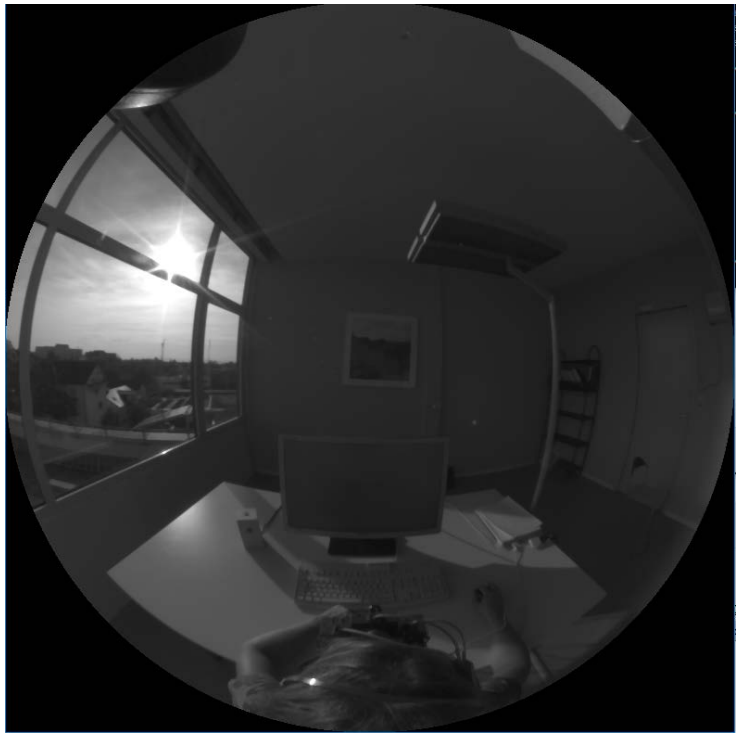
Glare and luminance

Reliable glare studies

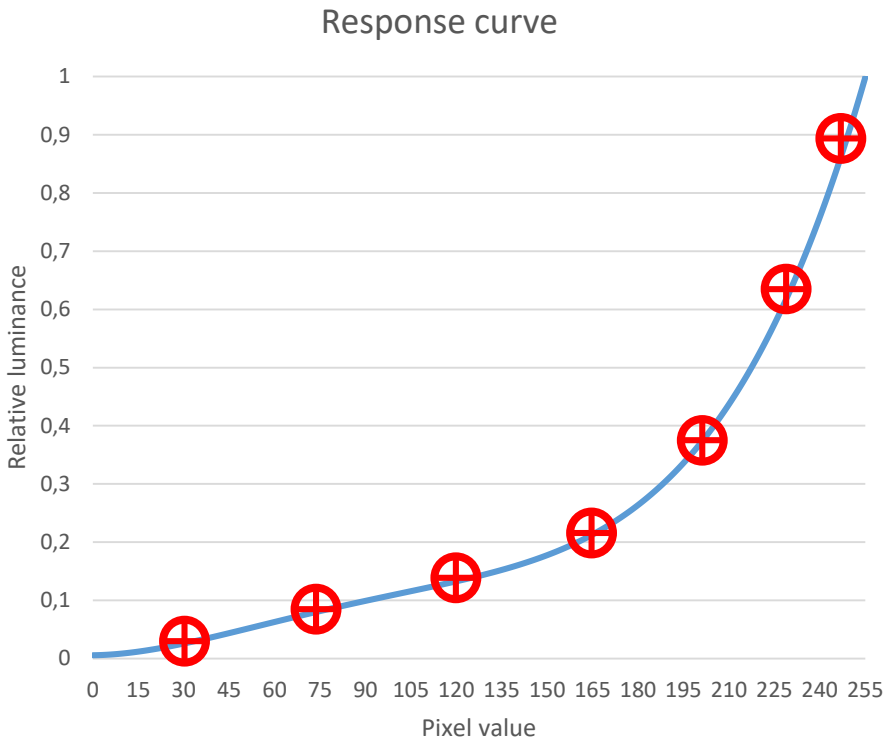
Reliable luminance measurements

2 different methods

- Absolute calibration
- ”Self-calibration”
  - Automatic algorithm



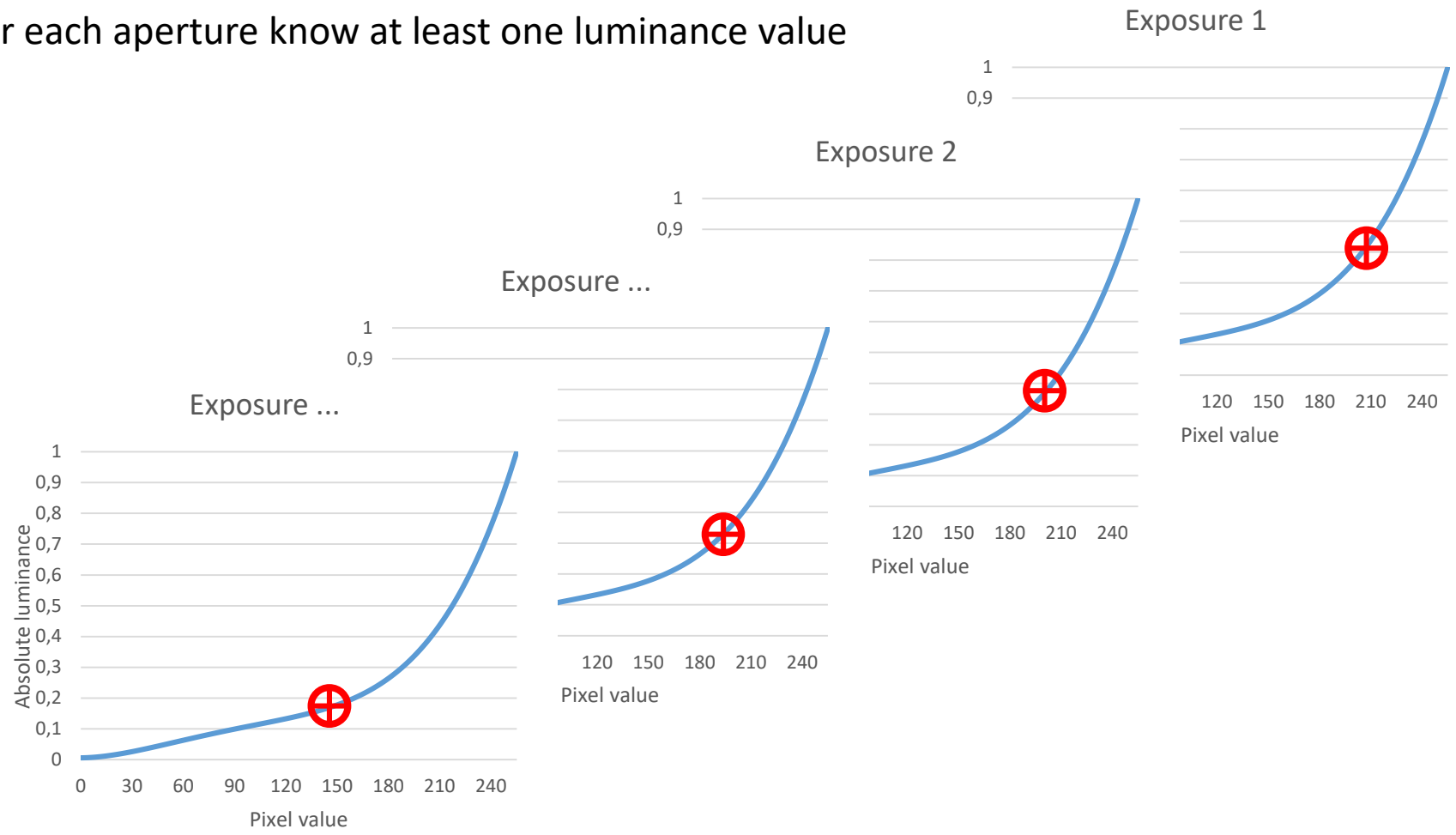
Absolute HDR camera calibration



The shape of the response curve

Absolute HDR camera calibration

For each aperture know at least one luminance value

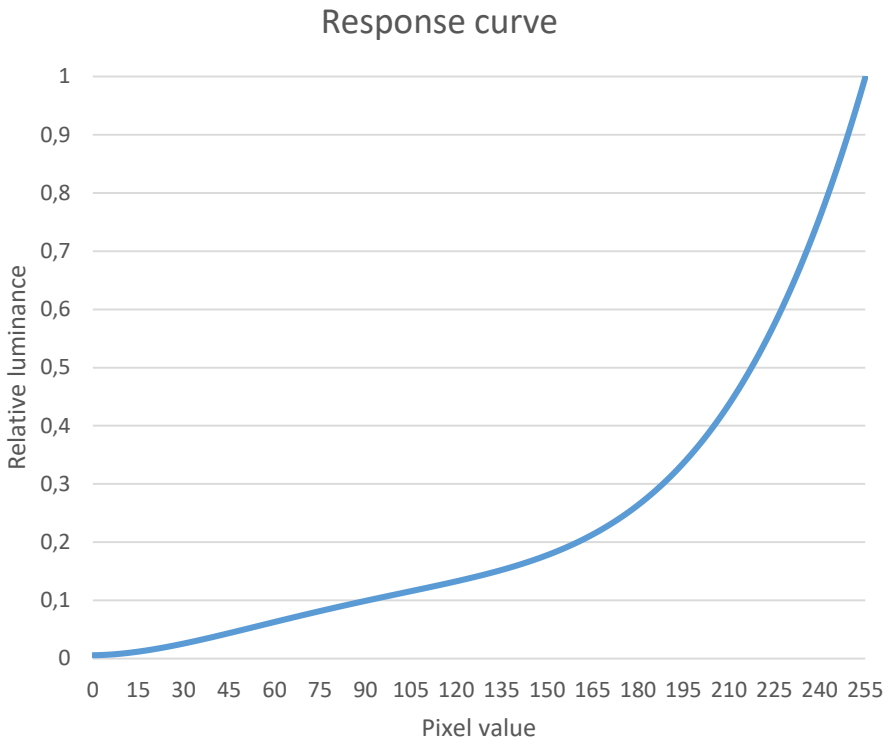


HDR generation

Luminance values calculated based on pixel value, response curve and exposure

Automatic algorithm HDR camera calibration

An automatic calibration algorithm is used to derive a response curve



$$20 < Pixel\ Value < 200$$

Automatic algorithm HDR camera calibration

Different programs

- PFSTools
- hdrgen
  - Photosphere
  - WebHDR

Use up-to-date versions – also of Radiance (current version 5.1)

DSLR camera “self/calibration” procedure

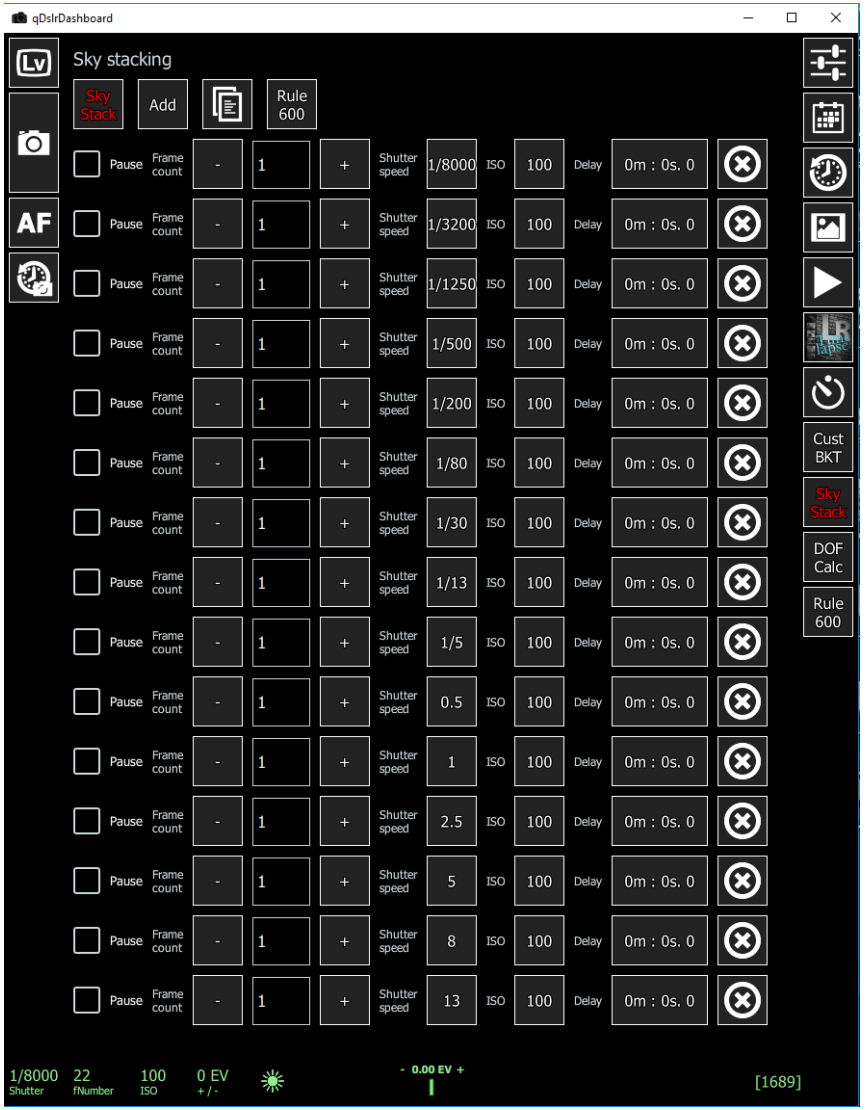
- Create LDR images
- Create HDR image
- Cut images
- Calibrate for vignetting
- Calibrate for projection
- Luminance calibration
- Illuminance check

General camera settings

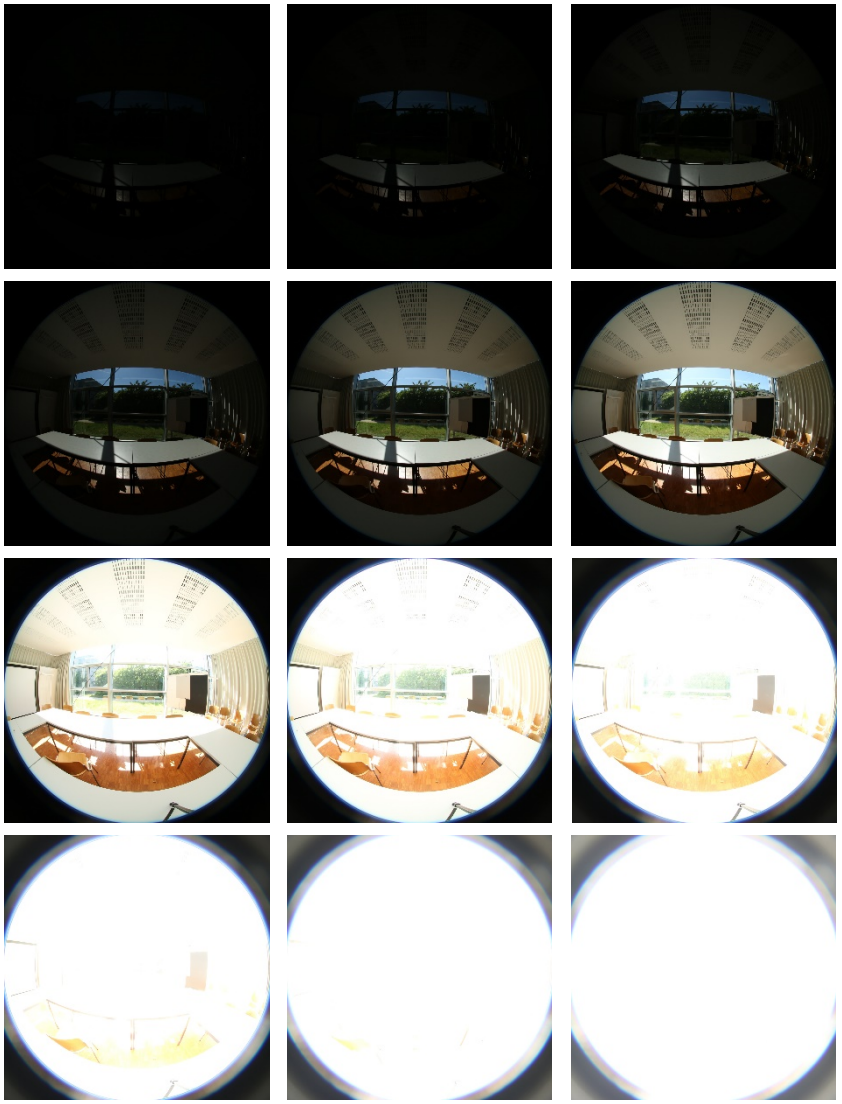
ISO speed	100
White balance	Daylight
Image quality	.JPEG (large)
Color space	sRGB
Focus	Infinity (auto off)
Picture style	Standard

General camera setup

- Auto bracketing
- Computer control
  - Manufactures
  - qDSLRdashboard



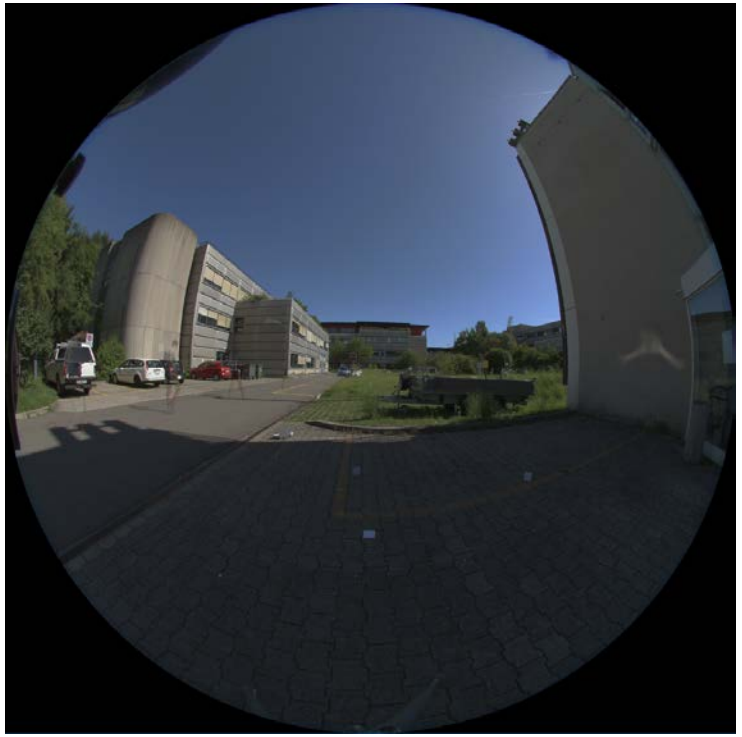
General camera setup



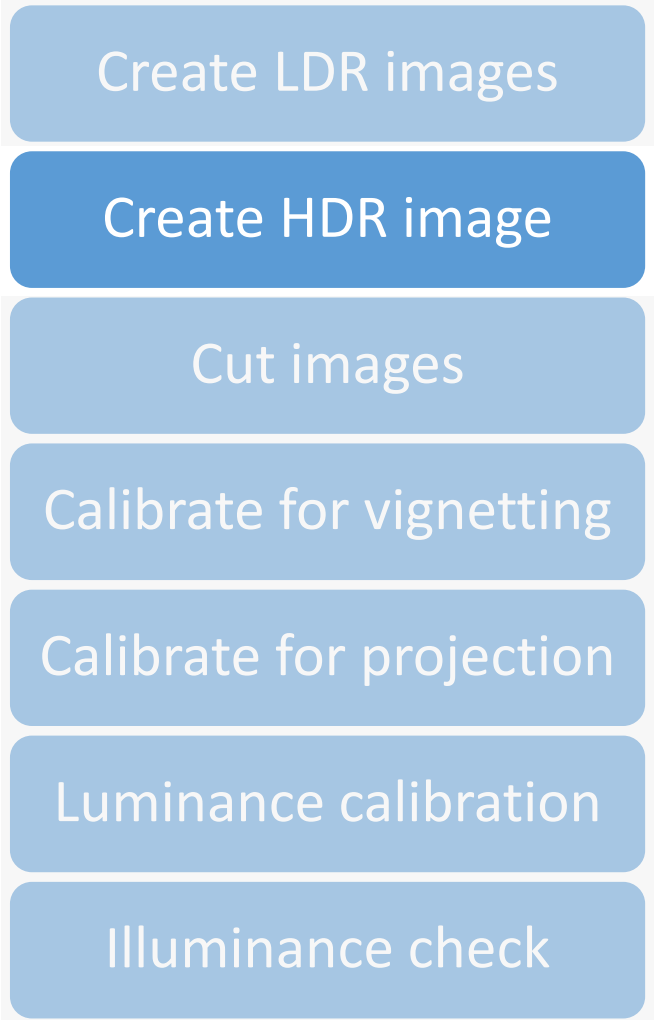
1 EV stop between images

General camera setup

- Avoid movement in scene (avoid ghosting)
- Avoid shaking camera
- Use a tripod
- Use a computer for bracketing
- Black to white image series
- Use targets in the scene
  - High luminance
  - Low luminance
- Measure vertical illuminance



DSLR camera “self/calibration” procedure



HDR generation

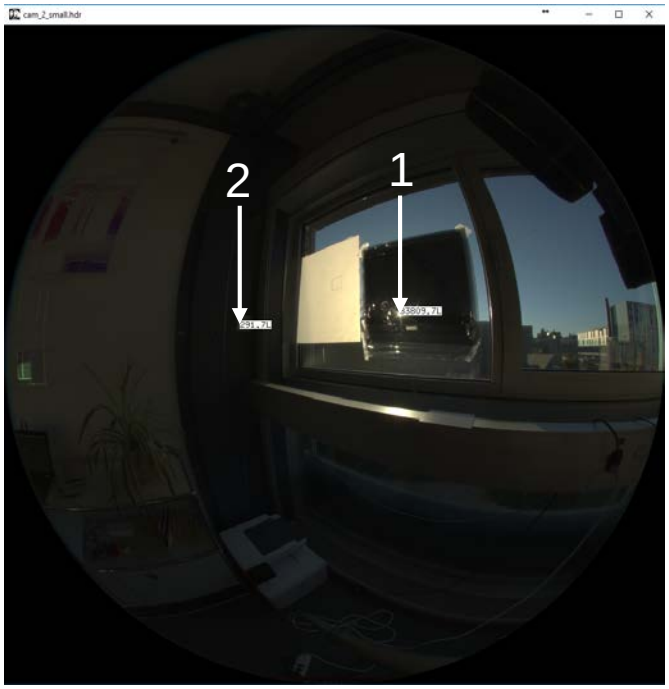
Generate HDR

hgrgen –o –r –a –e –f –g –x

- o = output file
- r = response curve file
- a = automatic exposure alignment
- e = exposure adjustment
- f = flare removal
- g = ghost removal
- ~~x = over and under exposure removal~~

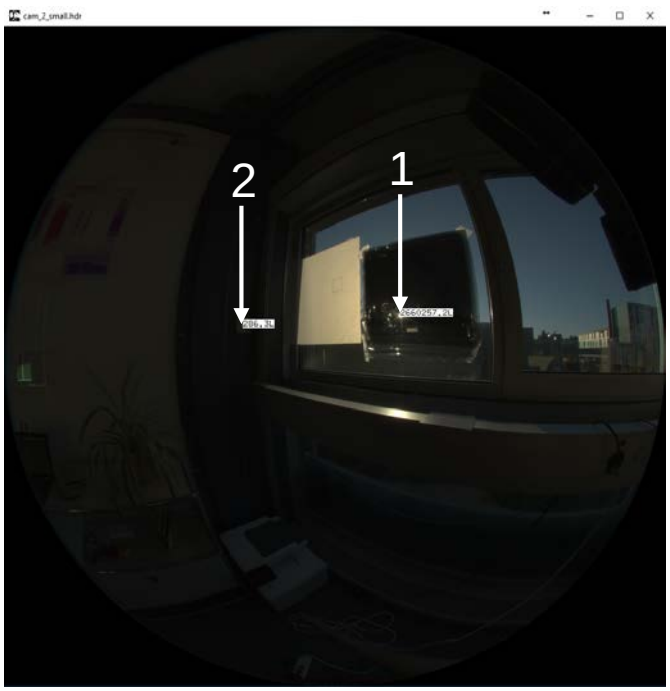
HDR generation

With –x option



1: 89.809 cd/m^2
2: 291 cd/m^2

Without –x option



1: 2.653.980 cd/m^2
2: 281 cd/m^2

Konica Minolta: 1: 1.674.000 cd/m^2
2: 275 cd/m^2

HDR generation

Check LDR images

- Darkest should not have pixels > 200
- Whitest should not have pixels < 20

Response curve

Scene should contain

- bright areas
- dark areas
- white and/or grey areas

Response curve – HDR generation

hgrgen –o –r –a –e –f –g → to generate HDR and curve

With –r option give name to response curve file

Save it and use it to make HDR images

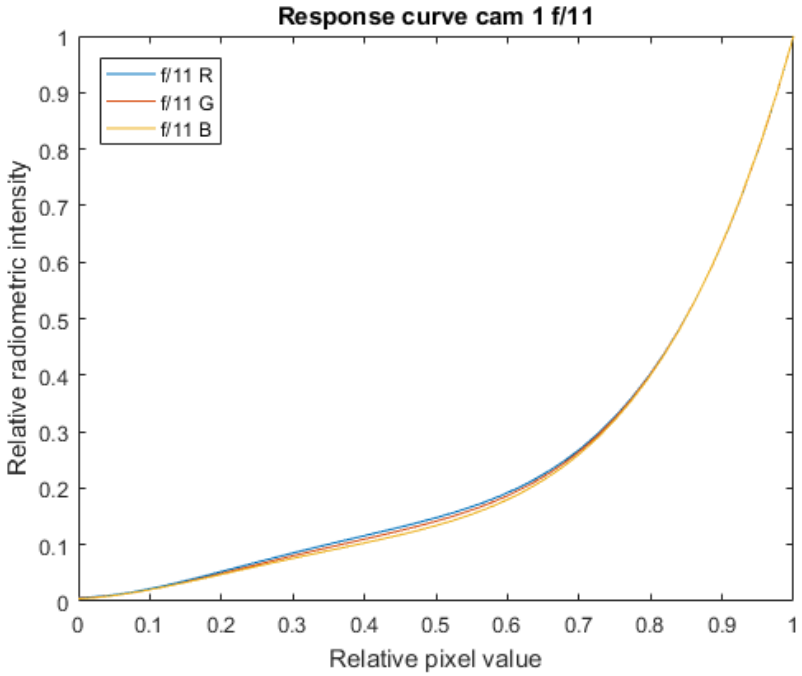
/home/phansen/Camera_calibration/Response_curve/Response_cam_1/11/11.rsp

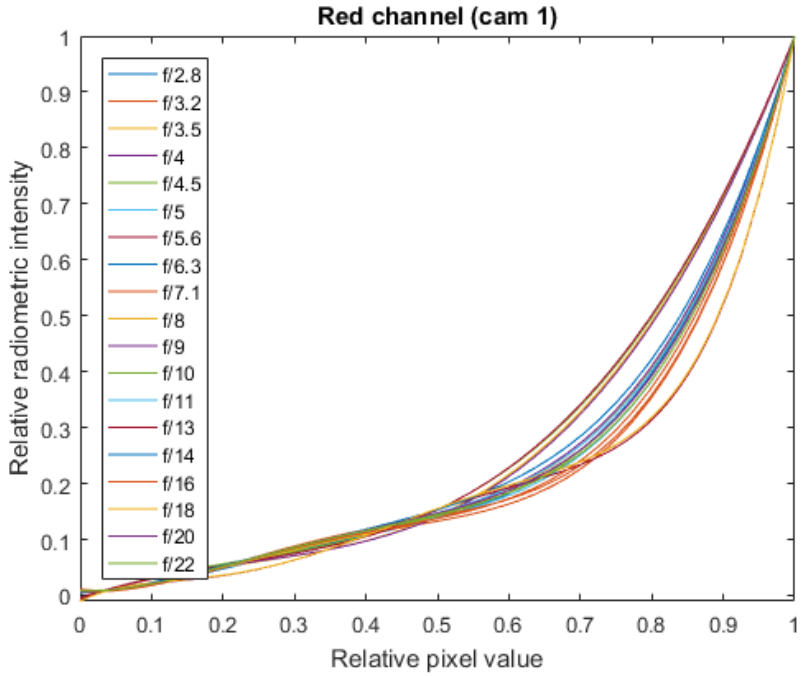
Encoding Colc

```
4 3.33299 -4.10854 1.75235 0.0167096 0.00648387
4 3.2037 -3.86379 1.63398 0.0207269 0.00537953
4 2.96702 -3.38244 1.35453 0.0567263 0.00416186
```

[n] degree polynomial

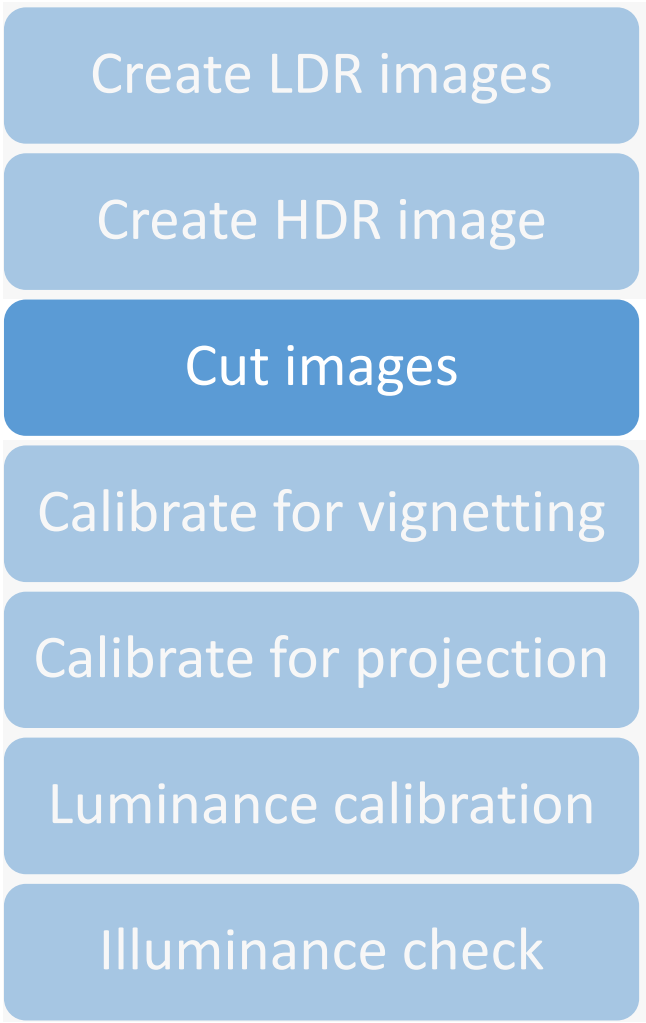
Response curve



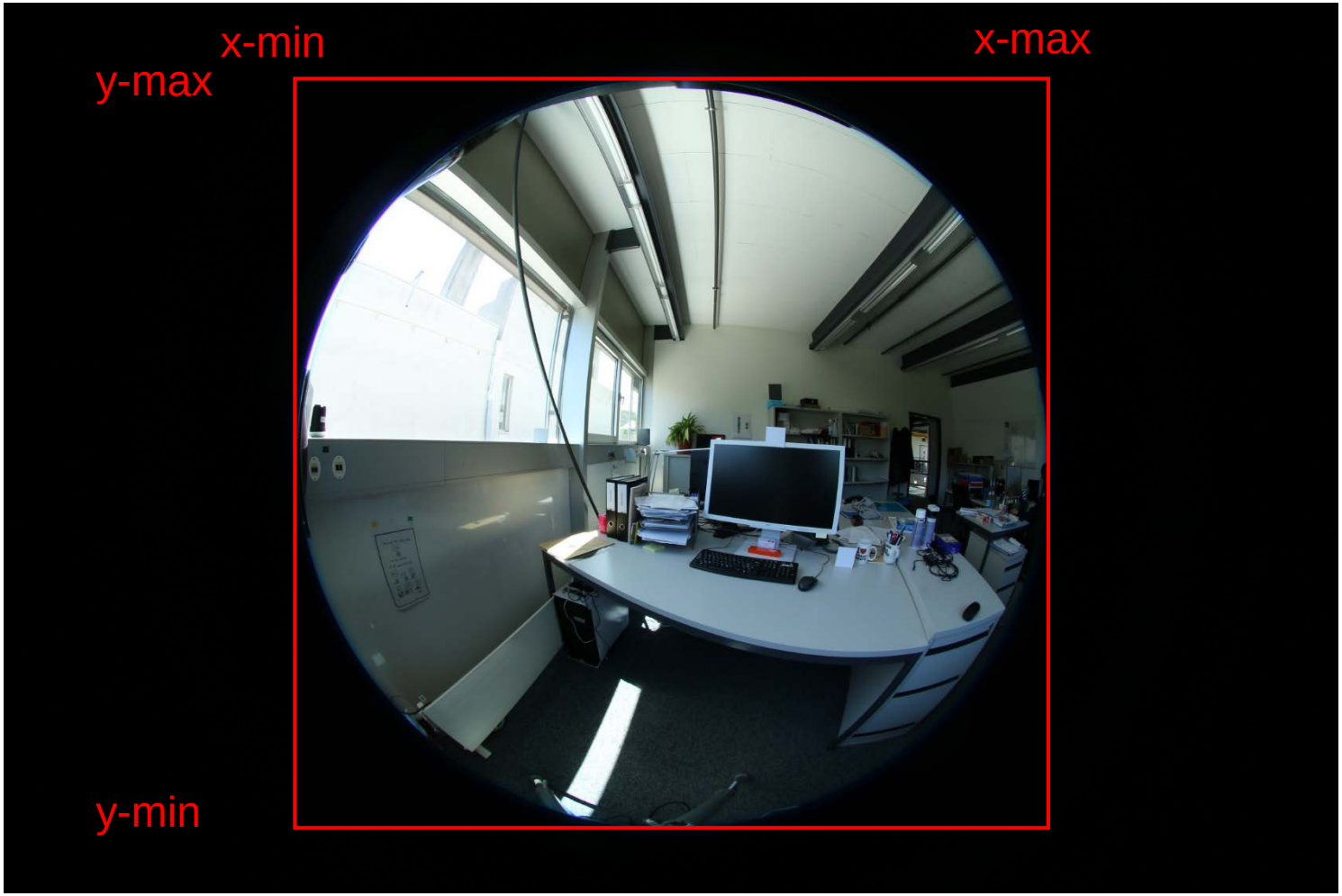


Differs for all cameras and apertures

DSLR camera “self/calibration” procedure

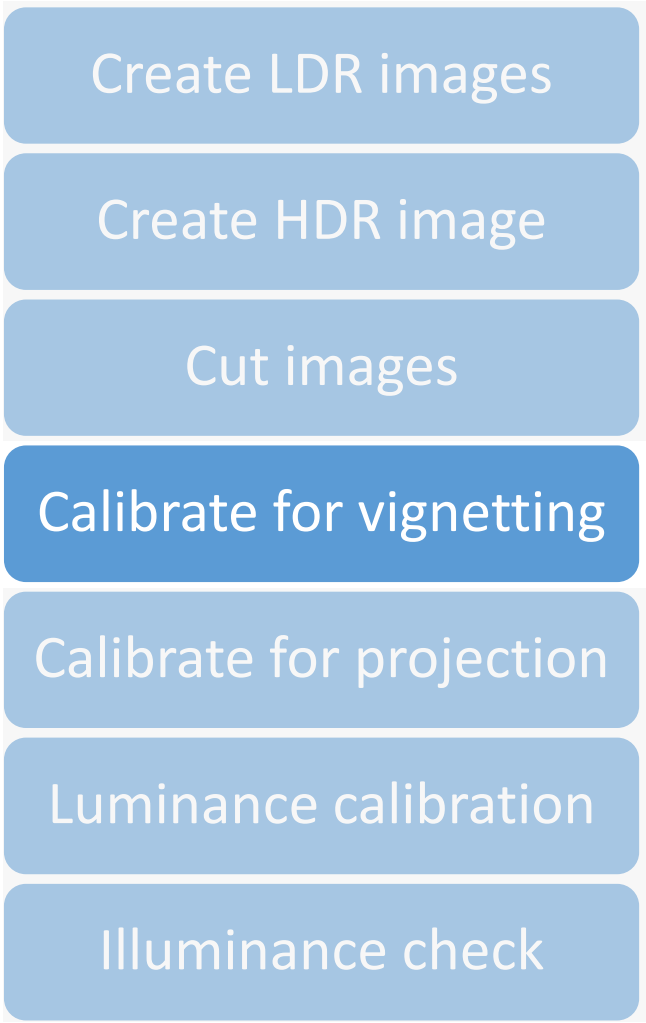


Cut HDR image

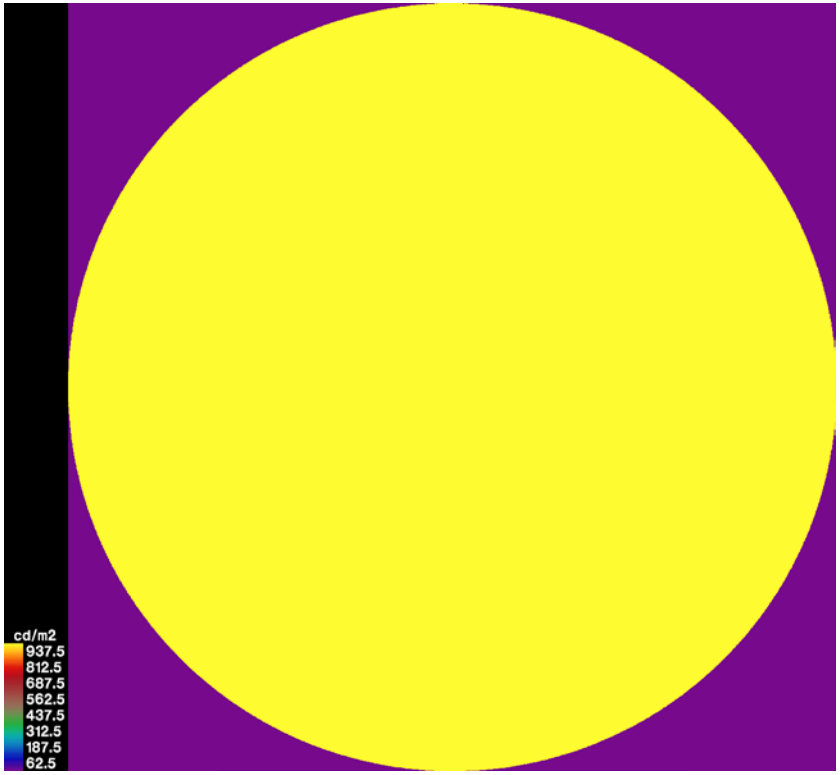


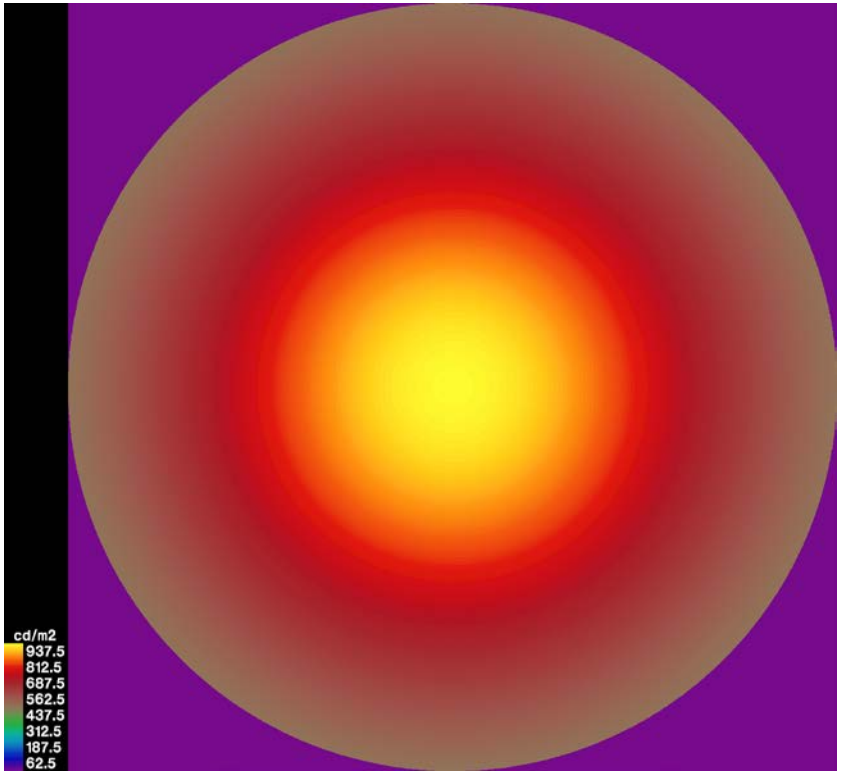
pcompos -x [x-max] -y [y-max] -h [org_image.hdr] -[x-min] –[y-min] > [cut_image.hdr]

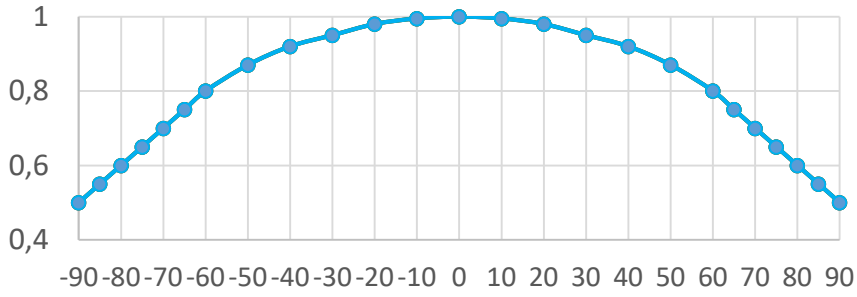
DSLR camera “self/calibration” procedure



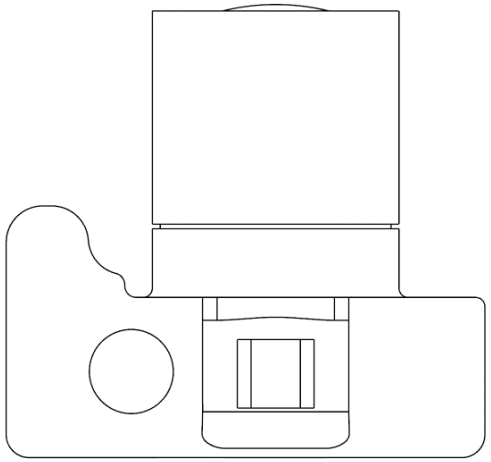
Vignetting


cd/m2
937.5
812.5
687.5
562.5
437.5
312.5
187.5
62.5

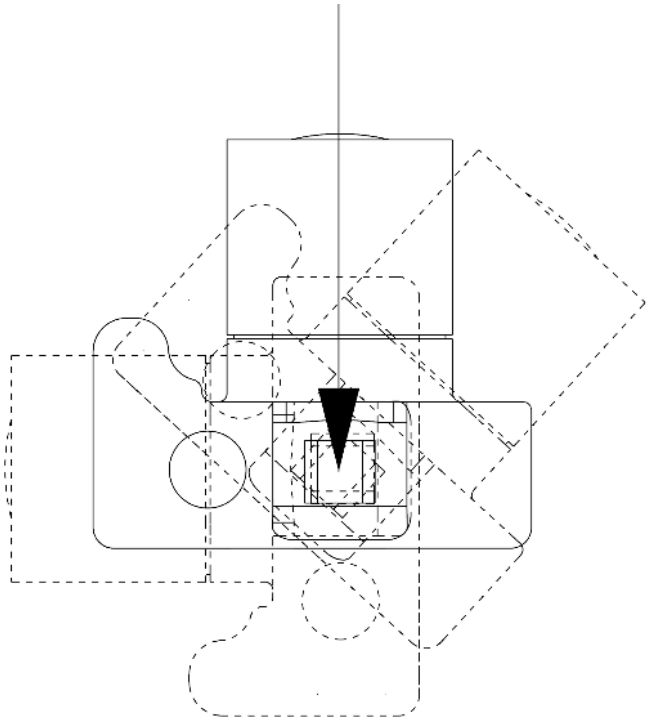

cd/m2
937.5
812.5
687.5
562.5
437.5
312.5
187.5
62.5


1
0,8
0,6
0,4
-90 -80 -70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90

Vignetting

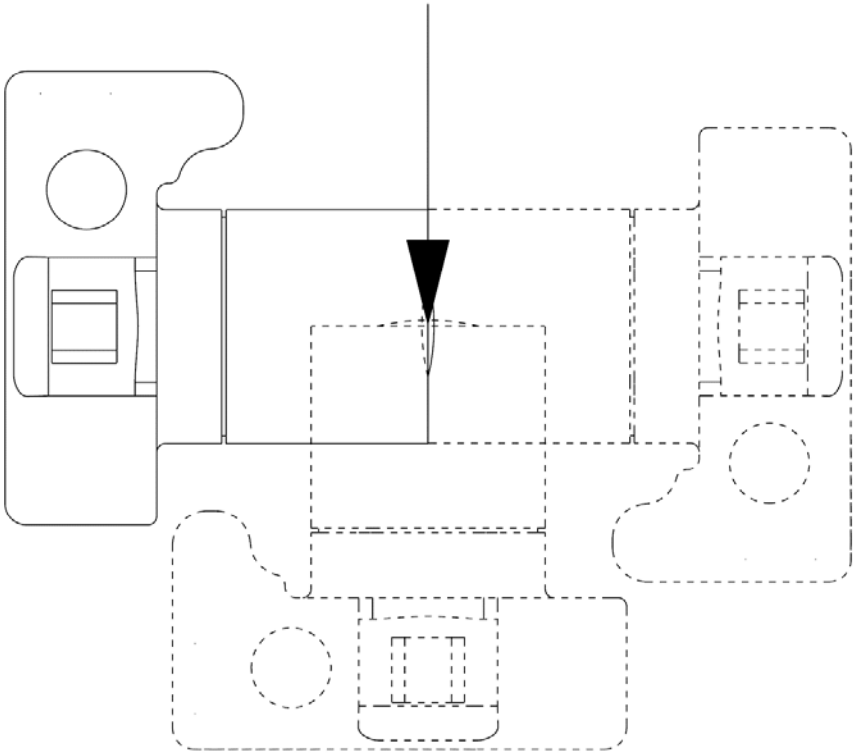


Normal camera rotation point

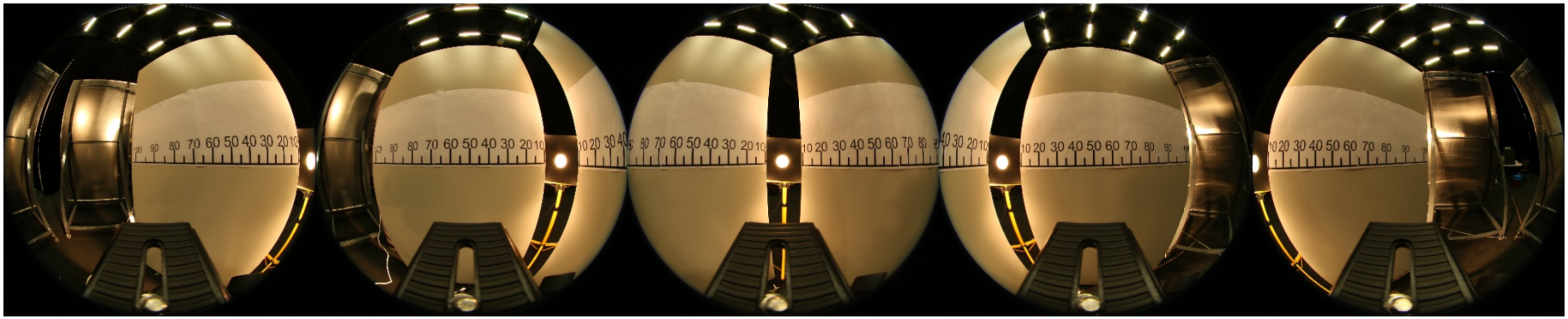


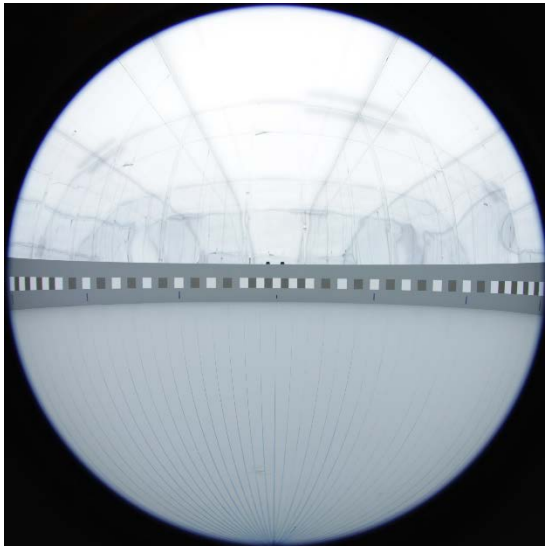
Vignetting

Nodal rotation point



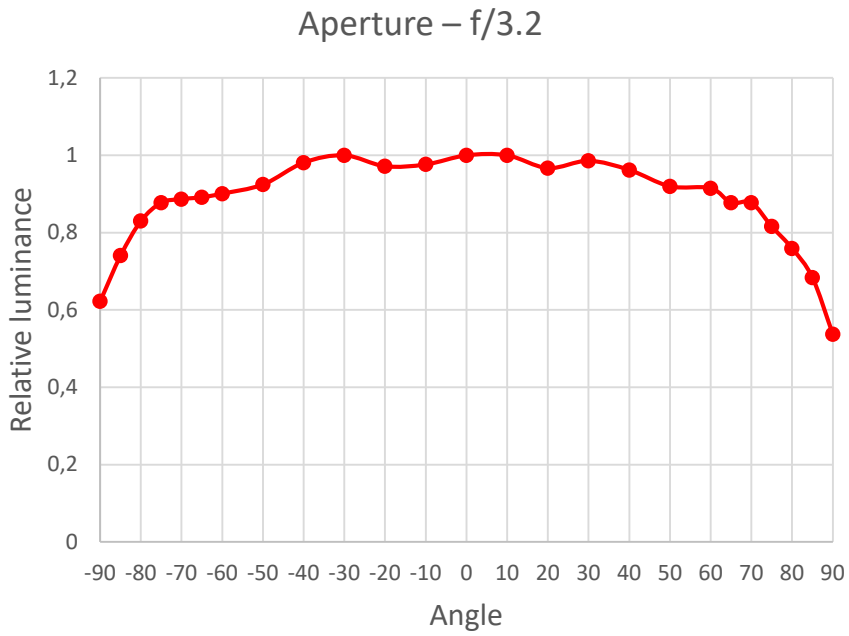
Vignetting

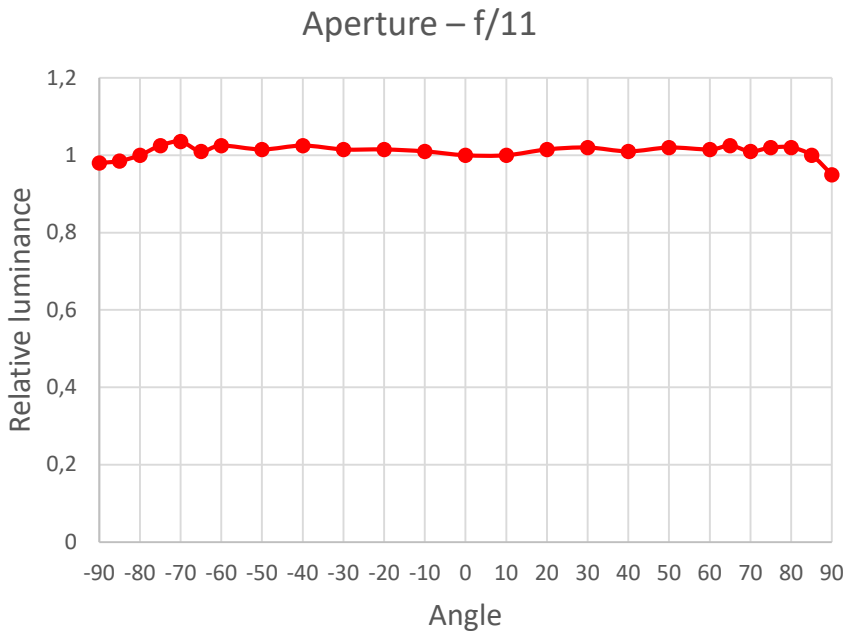




Second setup images curtesy of Clotilde Pierson

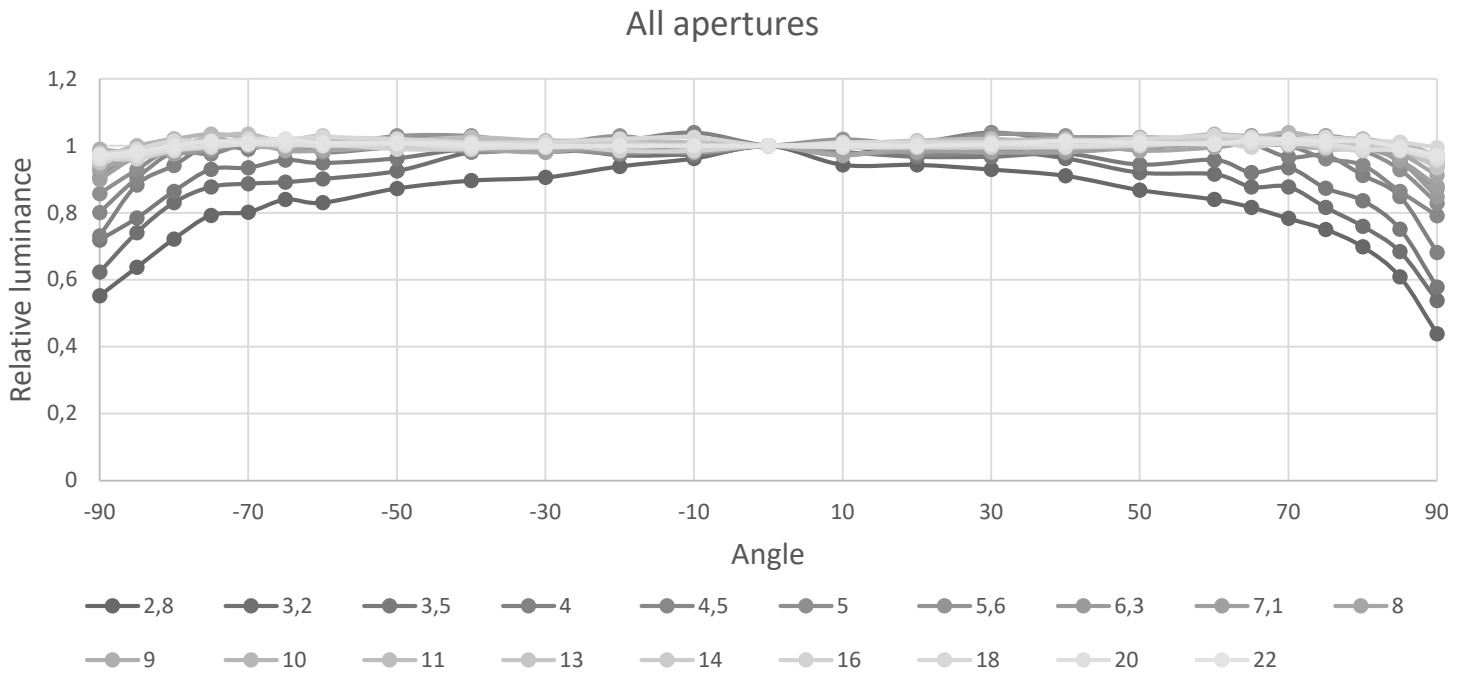
Vignetting





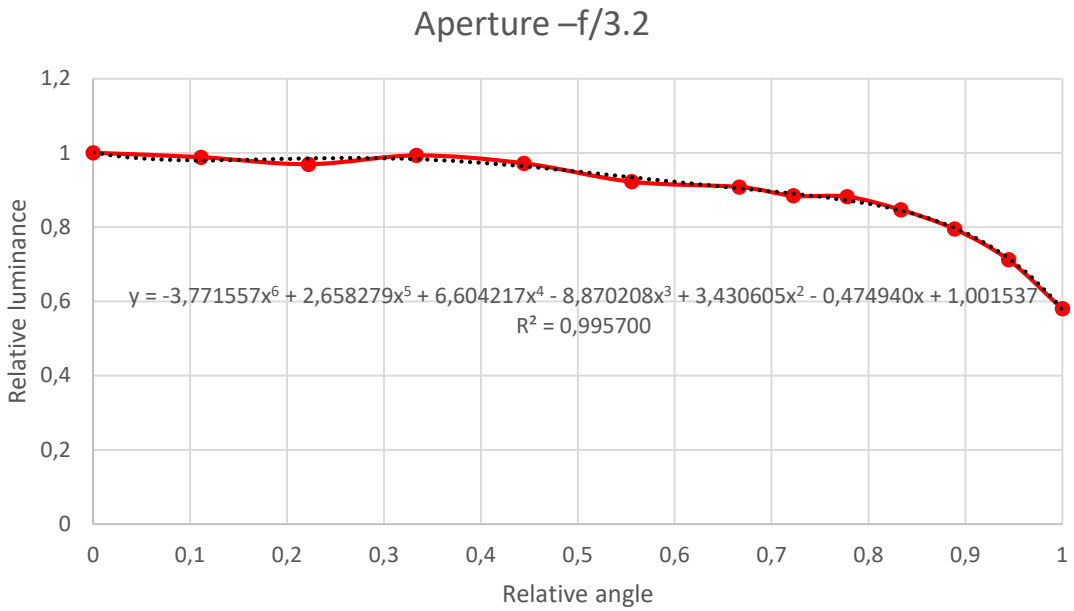
Normalized to lens center

Vignetting


All apertures
Relative luminance
1,2
1
0,8
0,6
0,4
0,2
0
-90
-70
-50
-30
-10
10
30
50
70
90
Angle
2,8
3,2
3,5
4
4,5
5
5,6
6,3
7,1
8
9
10
11
13
14
16
18
20
22

Vignetting

Establish 6th order polynomial for vignetting curve



Create a .cal file with the polynomial equation

Vignetting

Cal file example

/home/phansen/Camera_calibration/Vignetting_cal_files/cam_1/vig_cam1_ab_show.cal - phansen@lip...

Encoding Color

```
sq(x)=x*x;
r=sqrt(sq(x-1535)+sq(y-1535))/1535;
sf=1/(((F1)*(r^6))+((F2)*(r^5))+((F3)*(r^4))+((F4)*(r^3))+((F5)*(r^2))+((F6)*(r))+(F7));
ro=sf*ri(1);
go=sf*gi(1);
bo=sf*bi(1);
```

Line: 6/6 Column: 13 Encoding: 1252 (ANSI - La Modified

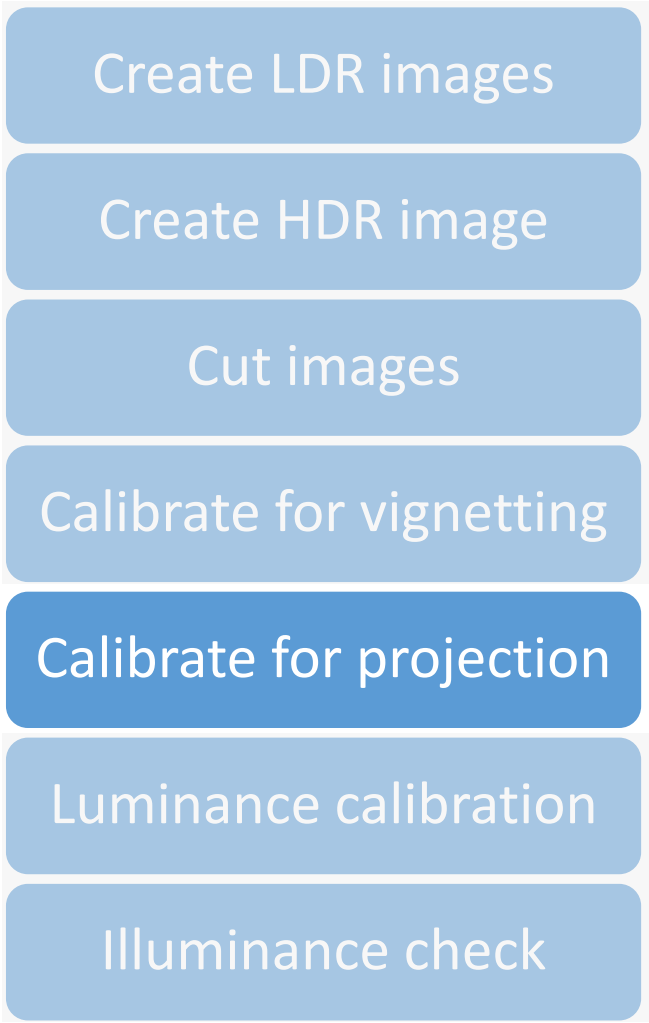
Apply to images with

pcomb –f [path_to/vignetting.cal] –o [original_image.hdr] > [corrected_image.hdr]

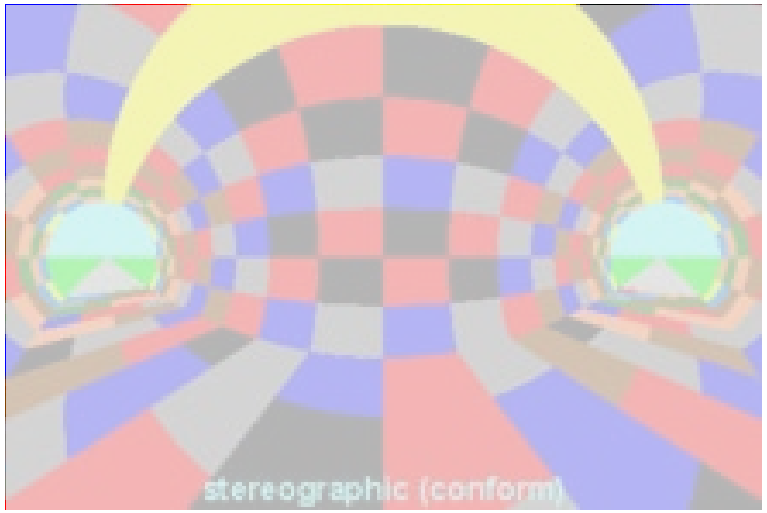
Vignetting

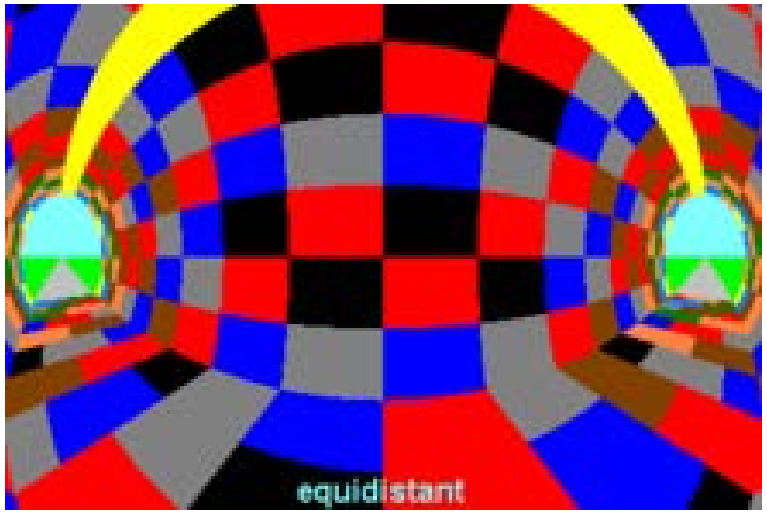
- Canon 70D
- Sigma 4.5mm f/2.8 fisheye lens

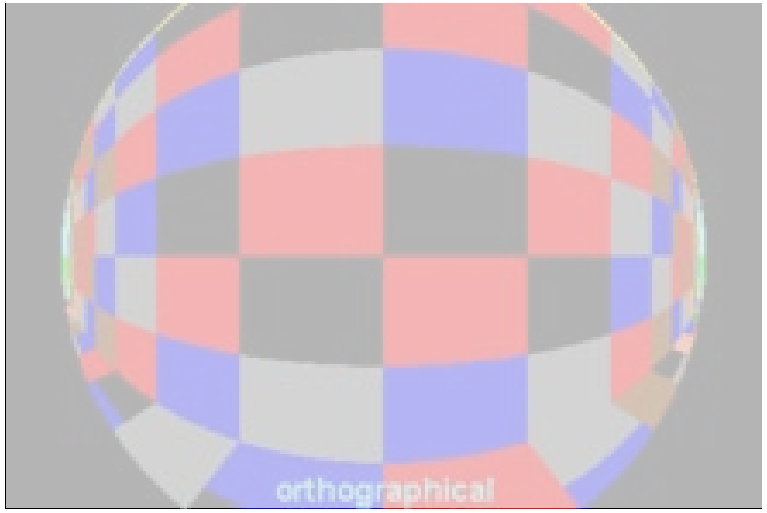
DSLR camera “self/calibration” procedure

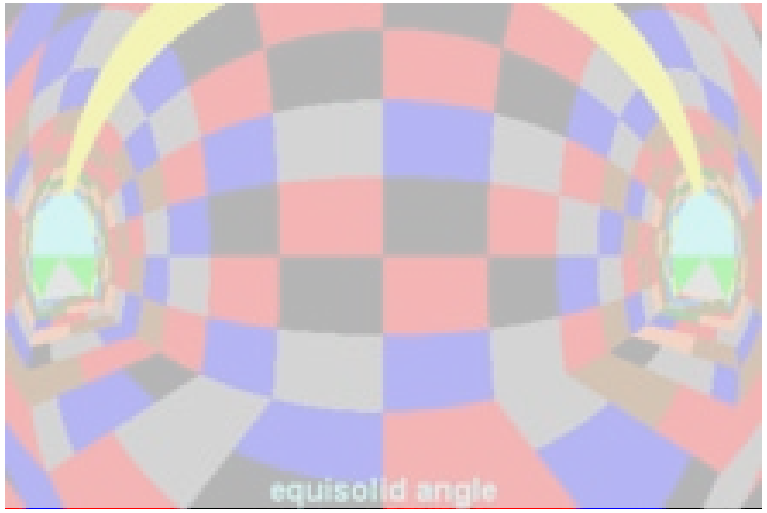


Projection

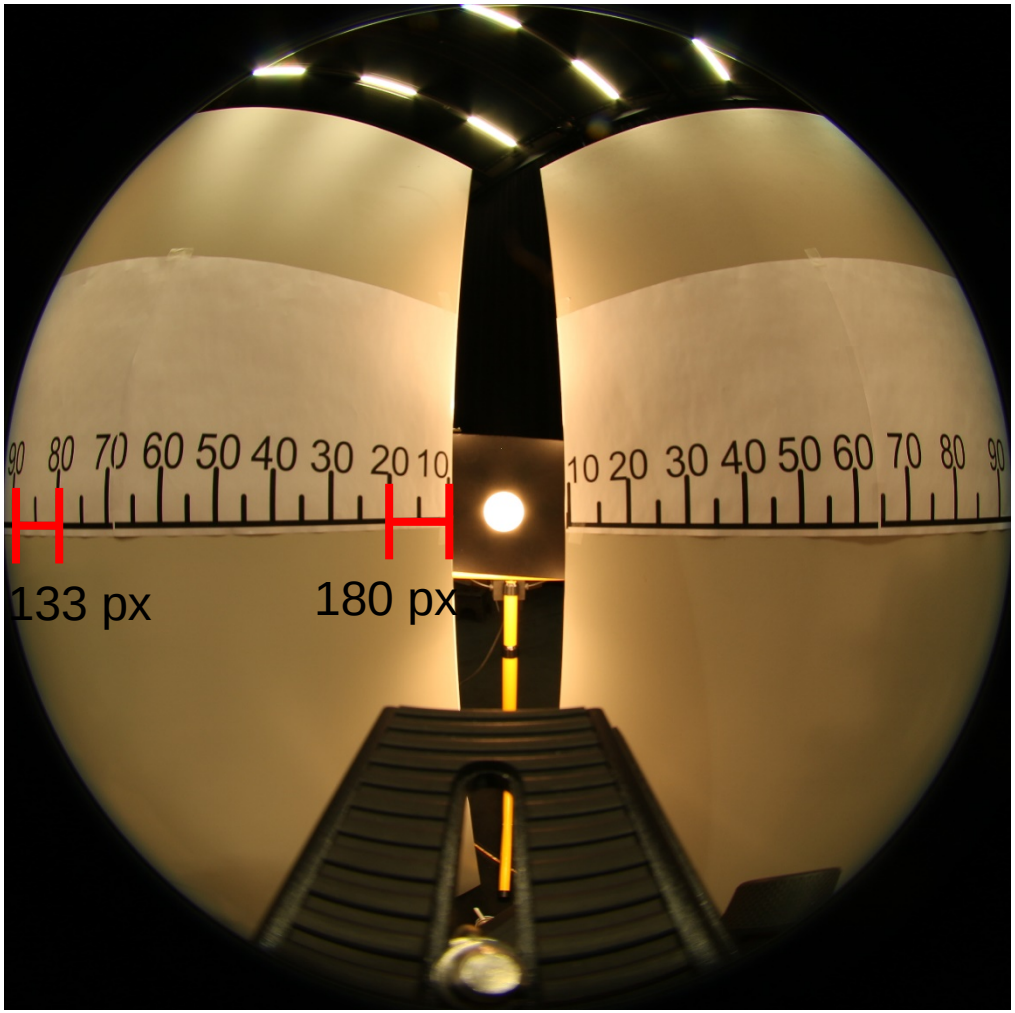

stereographic (conform)


equidistant


orthographical


equisolid angle

Projection



Projection

From Sigma:

4.5mm F2.8 EX DC HSM Circular Fisheye

EXAGGERATION TO THE MAX

Category: **Fisheye Lenses**
Typical Photography: **Landscape, Wedding & Events, Nature & Wildlife, Specialty**

- First circular fisheye designed for APS-C sensors
- 180 degrees angle of view for exaggerated close ups
- Carrying Case, front/rear caps & front adapter ring

Sigma's 4.5mm F2.8 EX DC Circular Fisheye HSM creates an image that is a circular, curved, distorted view of reality when used on a digital SLR camera. One of the most unusual lenses a photographer can use as it produces a circular image within a black surrounding frame. It is ideal for landscapes and panoramic photography. Because of its equisolid angle projection system, the lens can be used for scientific applications. The minimum focusing distance of 5.3 inches allows the photographer to have fun with placement of subjects extremely near to the camera with distorted backgrounds. SLD (Special Low Dispersion) glass employed for effective compensation of color aberration, Super Multi-Layer lens coating reduces flare and ghosting and assures high image quality throughout the entire focal range. In the hands of a photographer looking for creative expression and the opportunity to explore and create, this is the ultimate creative tool. The results are captivating

Projection

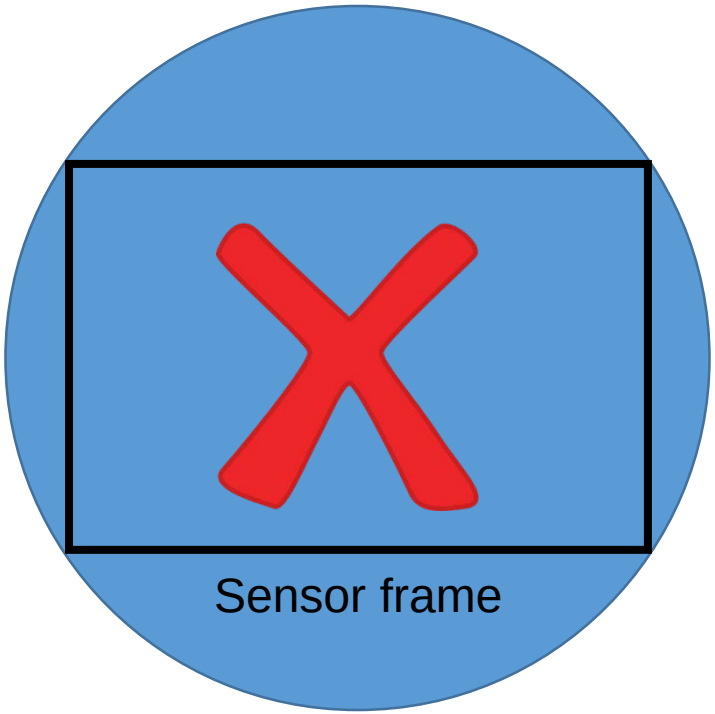
Fisheye correction file from:
https://www.radiance-online.org/cgi-bin/viewcvs.cgi/ray/src/cal/cal/

fisheye_corr.cal

pcomb –f [path_to/fisheye_corr.cal] -o [original_image.hdr] > [corrected_image.hdr]

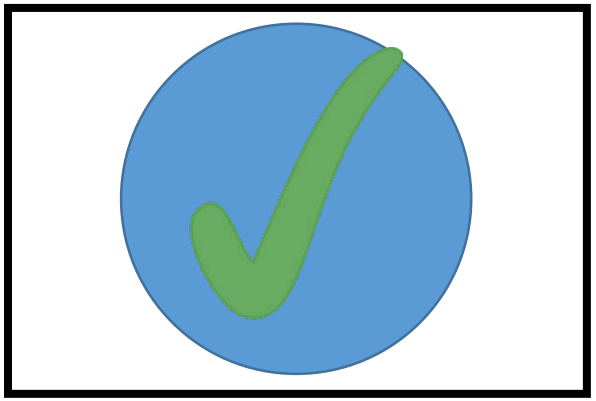
Projection

Also make sure the fisheye lens fits the sensor frame



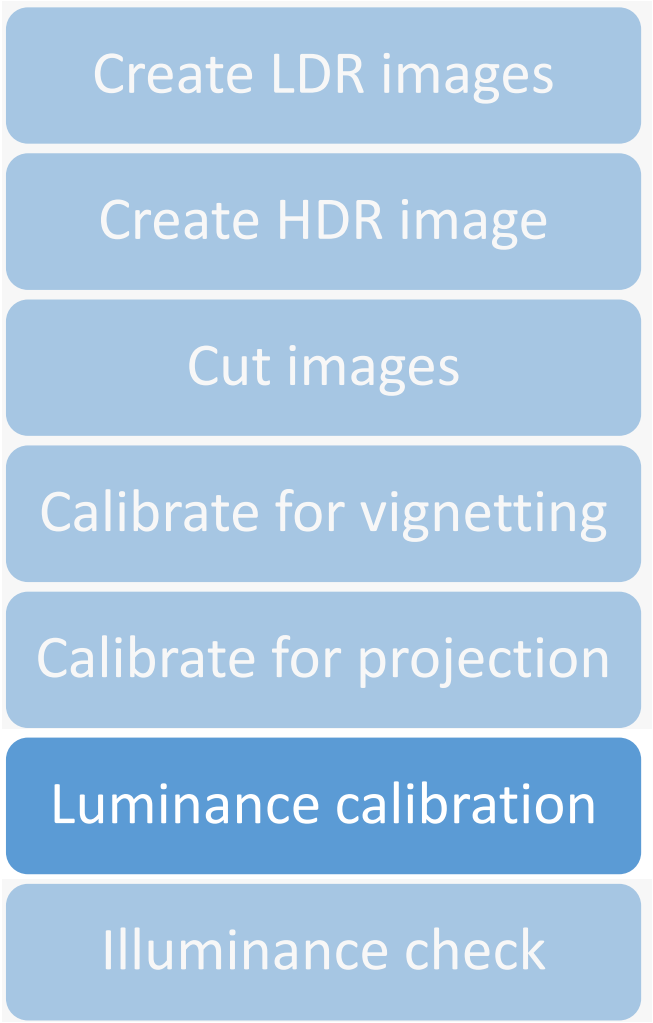
Projection

Also make sure the fisheye lens fits the sensor frame



Sensor frame

DSLR camera “self/calibration” procedure



Luminance adjustment

Target	Konica	Image	Factor
1	151	140,2	1,077
2	268	247,2	1,084
3	107	98,5	1,086

pcomb -s 1.08 -o [original_image.hdr] > [adjusted_image.hdr]

Should be less than ± 20 %

Luminance adjustment

Target	Konica	Image	Factor
1	151	151,1	0,999
2	268	266,2	1,007
3	107	107,8	0,993

pcomb -s 1.08 -o [original_image.hdr] > [adjusted_image.hdr]

Should be less than ± 20 %

Check header

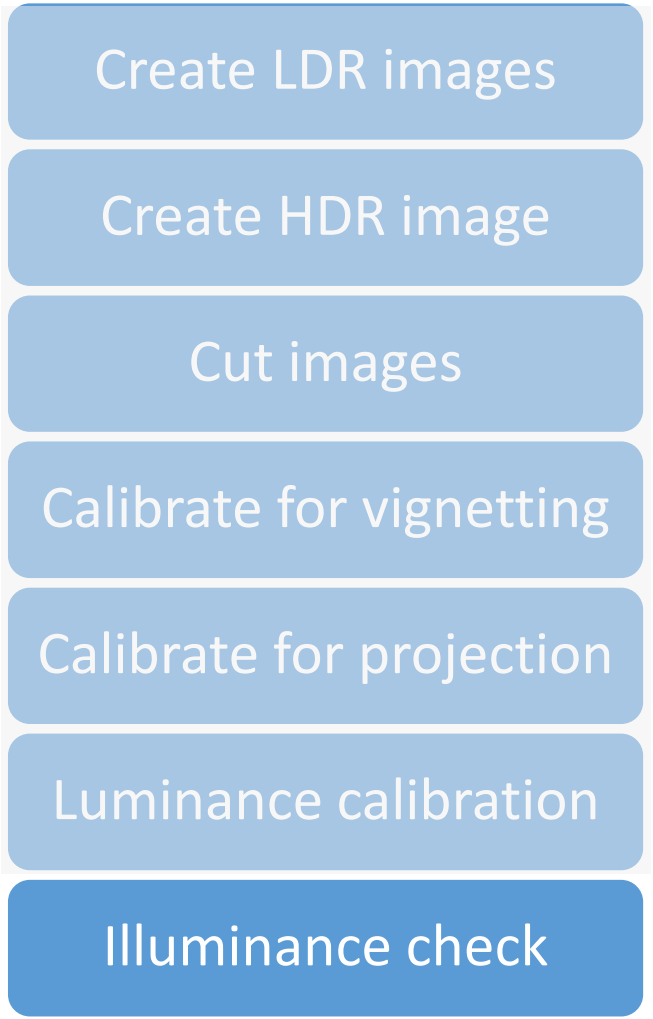
Remove or reset exposure to 1

Set “View” string to the right values (no “tab” in front)
-vta –vh 180 –vv 180

Remember to use the current version of Radiance (5.1 at the moment)

```
Lmk_corred_cam_1_ab_11.hdr:
        #?RADIANCE
        CAPDATE= 2017:06:29 11:37:53
        GMT= 2017:06:29 09:37:53
        cam_1_ab_11.hdr:
                CAPDATE= 2017:06:14 09:26:01
                GMT= 2017:06:14 07:26:01
                <stdin>:
                    CAPDATE= 2017:06:14 09:26:01
                    GMT= 2017:06:14 07:26:01
                    <stdin>:
                        CAPDATE= 2017:06:14 09:26:01
                        GMT= 2017:06:14 07:26:01
                        pcompos -x 3070 -y 3070 -h unmodified.hdr -1201 -278
                    pcomb -f /home/phansen/Camera_calibration/Vignetting_cal_files/fisheye_corr.cal -o -
        VIEW= -vta -vh 180 -vv 180
                pcomb -f /home/phansen/Camera_calibration/Vignetting_cal_files/cam_1/vig_cam1_ab_11.cal -o -
        pcomb -s 1.07298 -o cam_1_ab_11.hdr
        FORMAT=32-bit_rle_rgbe
```

DSLR camera “self/calibration” procedure



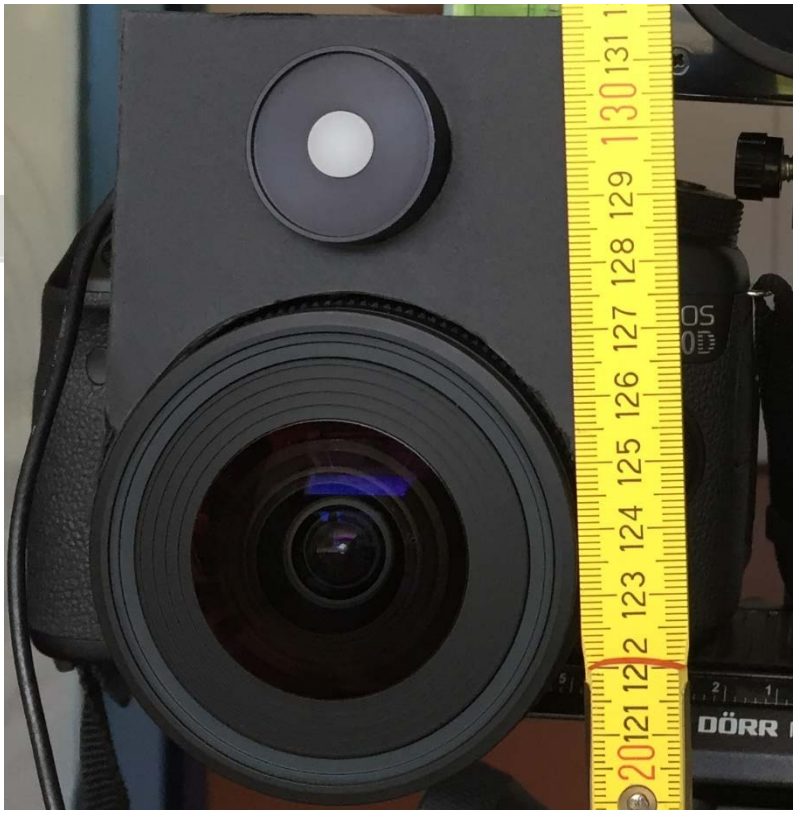
Illuminance check

Measure illuminance in scene

Calculate from HDR image

Lmk_corred_eval_clean

11	No_pixels	x-pos	y-pos	L_s	Omega_s
1	146273.000000	548.138720	769.993411	3357.884426	0.1127824894
2	3.000000	279.000336	1110.000000	1999.802020	0.0000022629
3	2.000000	443.000000	1273.500025	2011.721328	0.0000016632
4	412.000000	1082.261677	1491.465030	2196.412373	0.0004160032
5	8359.000000	1157.213786	1884.209079	5513.991263	0.0083511873
6	16675.000000	1271.252523	2701.581125	2160.390304	0.0133116894
7	33.000000	1235.044517	170.280991	1894.201050	0.0000239151
8	13191.000000	1329.322421	1280.083440	4493.945960	0.0135398500
9	351.000000	1459.133435	2201.706501	2706.522290	0.0003393716
10	14.000000	1689.714460	160.787383	2331.739558	0.0000102313
11	87.000000	[illegible]	1653.963323	2256.372362	0.0000768987
dgp	av_lum	E_v	lum_backg	E_v_dir	dgi
0.240698	372.554743	1145.877970	297.405506	211.175223	15.281463



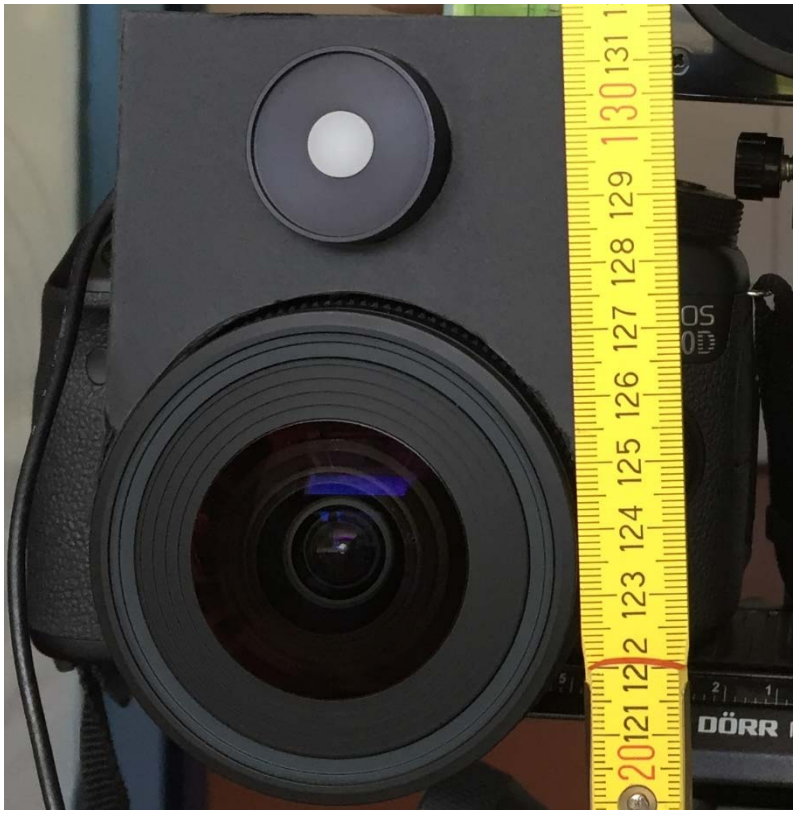
LMT	Image	Factor
1150	1145,8	1,004

Illuminance check

Do **NOT** use this to adjust luminance

This is a check that the “energy balance” of the image is correct

± 10 % is okay but should be random



High luminance scenes

High luminance scenes

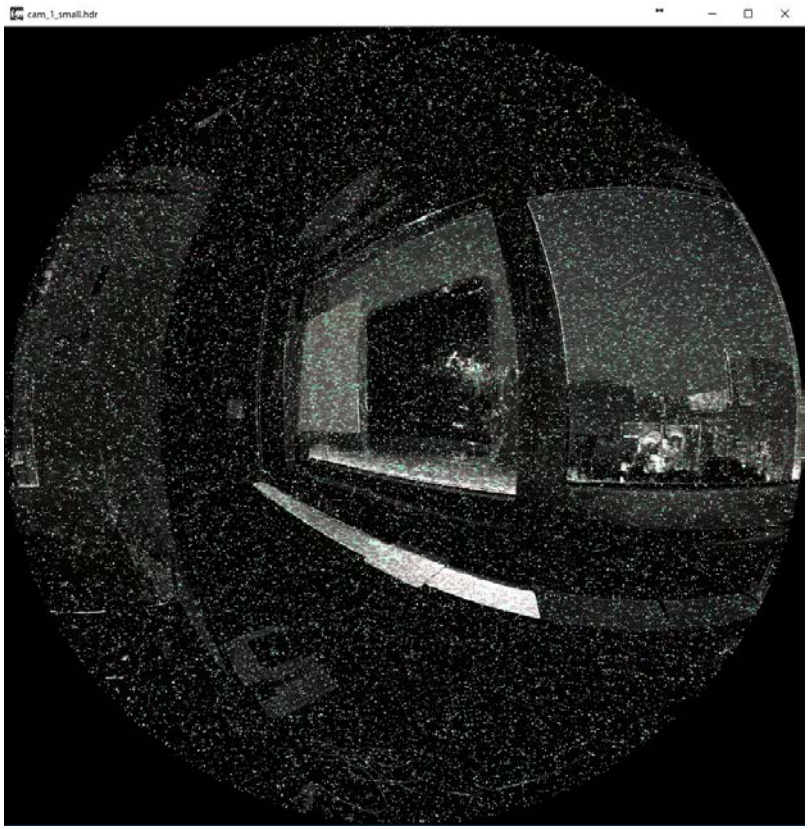
Be careful - long exposures with very high luminance can “burn out” the image sensor

High luminance scenes

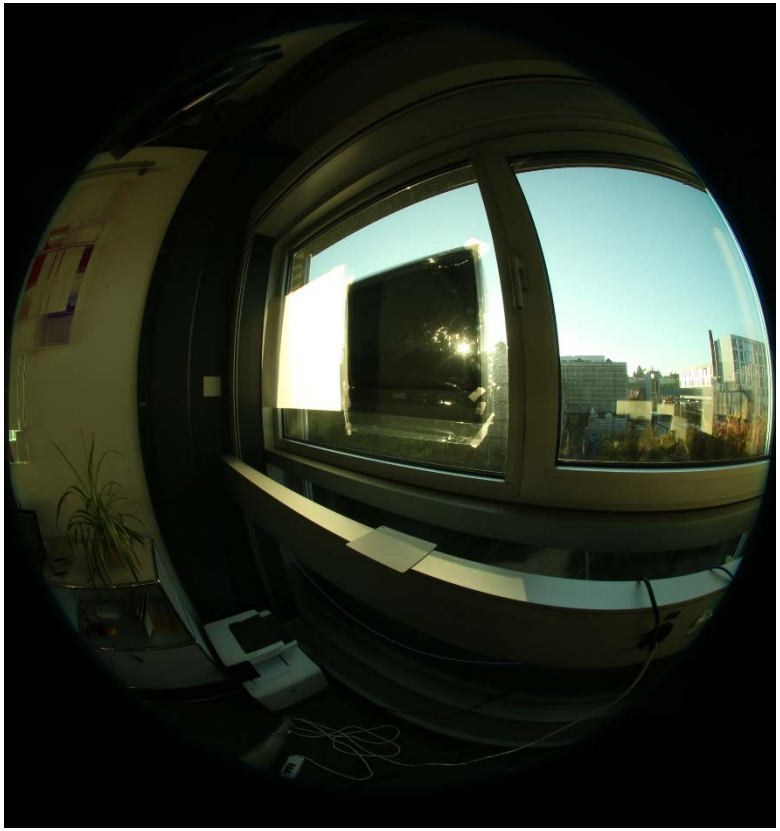
Use filters to reduce light on sensor

High luminance scenes

However, filters raises other problems



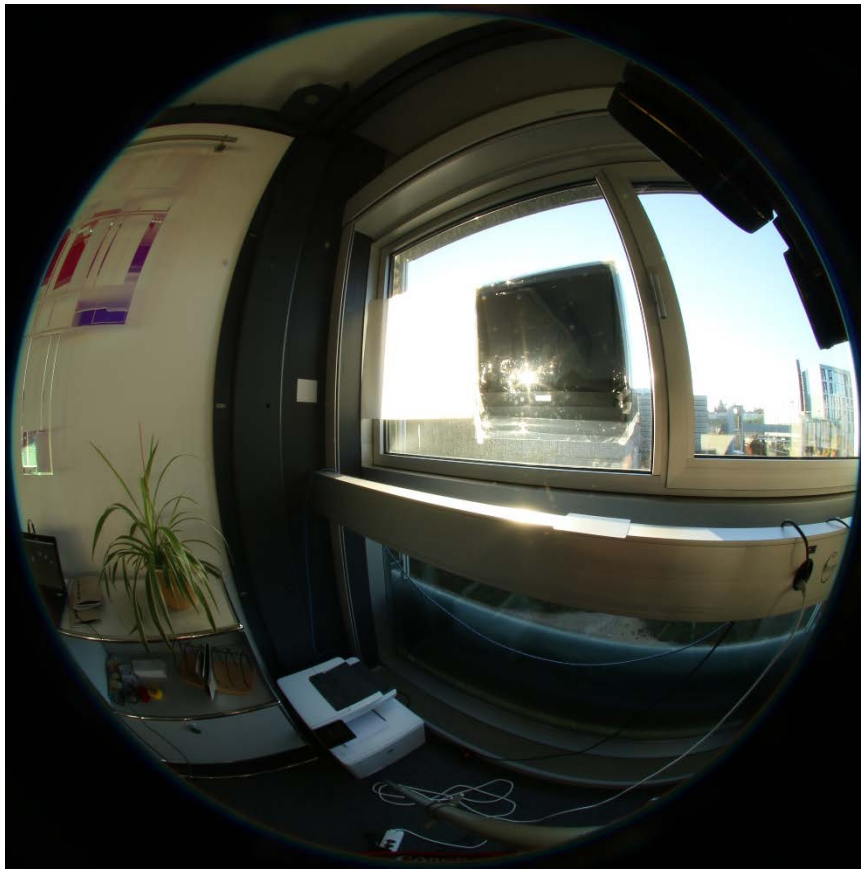
Grainy HDR



30 sec exposure at f/11

High luminance scenes

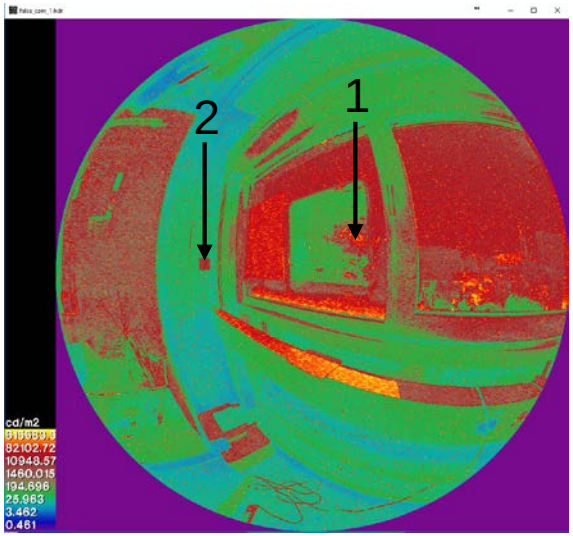
6 layers of 0,3 filters on window



High luminance scenes

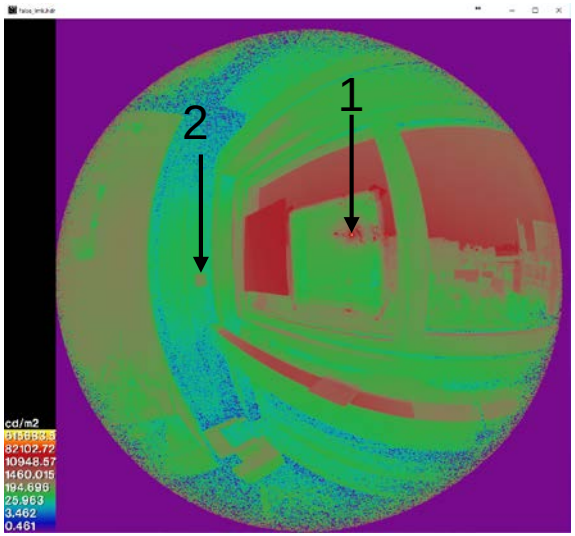
6 layers of 0,3 filters on window

Canon 0.1 % filter



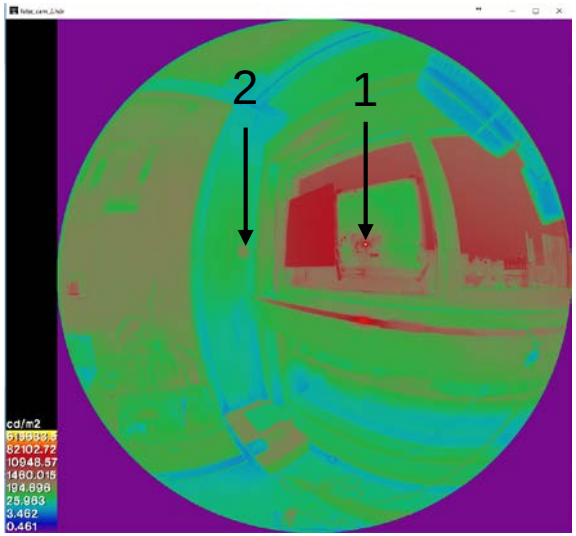
1: 762.973 cd/m^2
2: 12.110 cd/m^2

TechnoTeam 0.01 % filter



1: 1.651.000 cd/m^2
2: 274 cd/m^2

Canon no filter



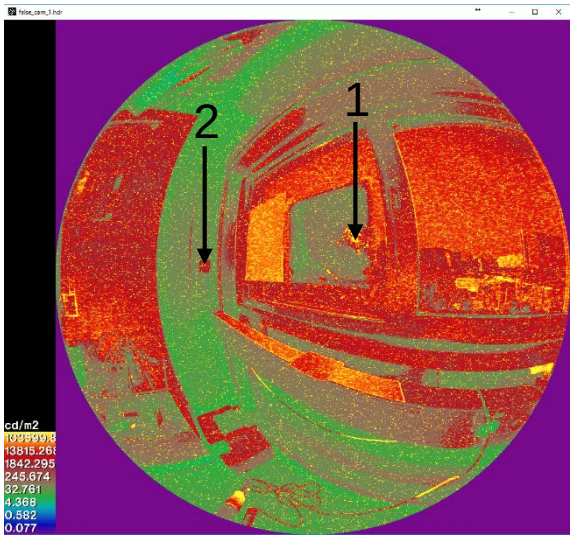
1: 2.653.980 cd/m^2
2: 281 cd/m^2

Konica Minolta: 1: 1.674.000 cd/m^2
2: 275 cd/m^2

High luminance scenes

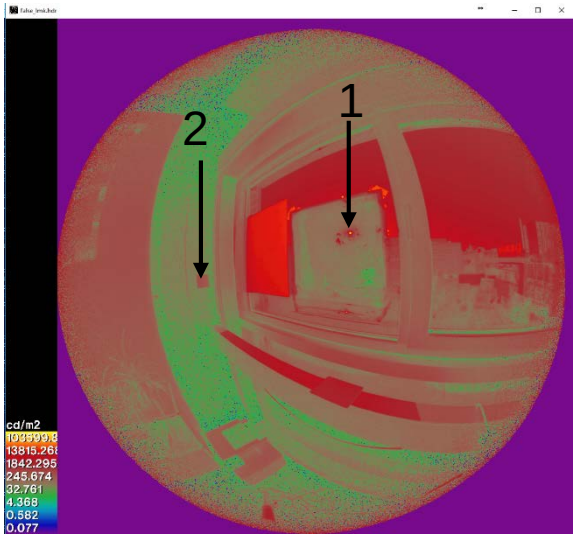
8 layers of 0,3 filters on window

Canon 0.1 % filter



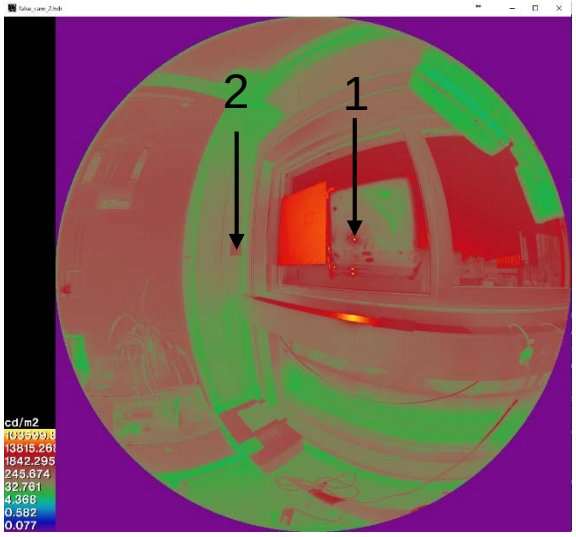
1: 342.192 cd/m^2
2: 28.125 cd/m^2

TechnoTeam 0.01 % filter



1: 264.000 cd/m^2
2: 327 cd/m^2

Canon no filter



1: 388.479 cd/m^2
2: 350 cd/m^2

Konica Minolta: 1: 261.000 cd/m^2
2: 313 cd/m^2

High luminance scenes

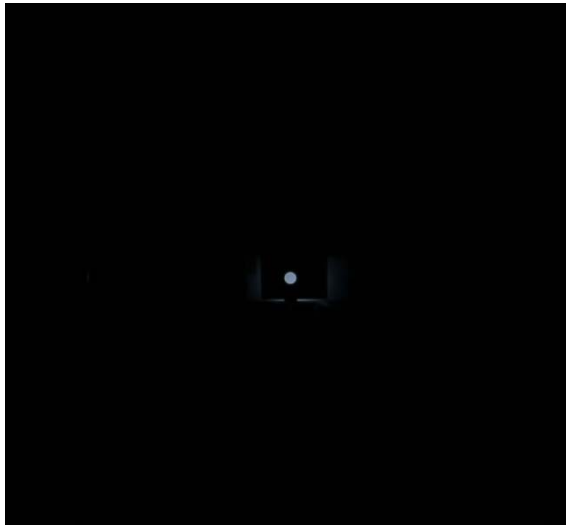
Avoid very high luminances

Check that the recorded values are correct

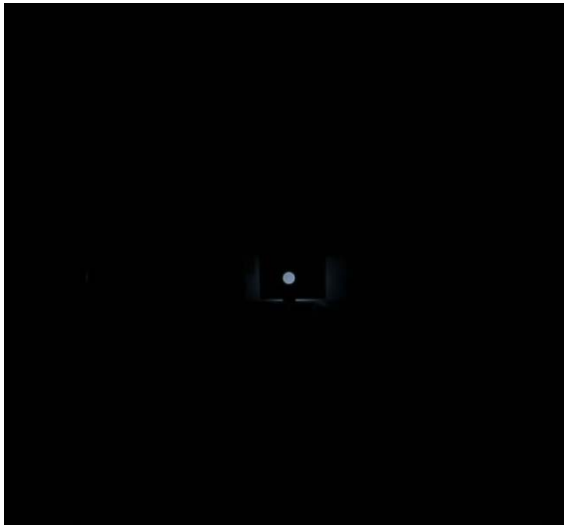
Other

Avoid flicker

- Influences pixel values



R: 159
G: 181
B: 203



R: 148
G: 162
B: 189

Synthesis

When “self-calibrating”

- Use recommended camera settings
- Use a tripod
- Create good response curves
- Correct for vignetting
- Correct for projection
- Luminance adjust
- Check vertical illuminance
- Check the header
- Be careful with very high luminance

Use the forums; Radiance HDRI is a good start
https://www.radiance-online.org/community/mailing-lists